11.7 Images in Plane Mirrors

You are standing in front of a mirror in the bathroom while brushing your teeth. You notice that the writing on your T-shirt seems backwards. You have always wondered why the writing on the hood of a police car or ambulance appears backwards. What exactly is going on here? Let's begin by doing the activity "Writing Reflectively." Can you write a message that can be read in a mirror? Here is your chance to try!

READING TIP

Using What You Know

If a question is posed in a paragraph, stop reading immediately after the question. Continue reading only after you tried to answer the question.

TRY THIS WRITING REFLECTIVELY

SKILLS MENU: Questioning, Performing, Observing, Evaluating, Communicating

SKILLS HANDBOOK 7.A.3.

Equipment and Materials: plane mirror; mirror supports (optional); a sheet of paper; pencil

1. Place the mirror on the upper half of the sheet of paper. You can use mirror supports or your hand to hold the mirror.
2. While looking into the mirror, carefully print your name on the piece of paper so that it appears correctly in the mirror, not on the page. You may have to practise a few times until you are able to do this successfully. Also, try writing with the hand that you do not usually use.
3. Once you are comfortable with writing using a mirror, use the mirror to carefully print a short message.
4. Exchange your message with a partner. Try to decipher the message that you have received from your partner. Check the accuracy of your translation of your partner's message by using a mirror.

A. Describe the appearance of your written name on the paper compared with its appearance in the mirror. T/I

B. Was writing while looking into a mirror difficult? Why? Which letters did you find more difficult to do? T/I

C. Did you find it easier writing with one hand than with the other? If so, suggest a reason why. T/I

D. From this activity, what general conclusion can you make about how an object and its image in a plane mirror are related? T/I

E. Leonardo da Vinci was a left-handed Italian artist and scientist born in the 15th century. He used mirror writing in his notebooks when he was writing about his inventions and other ideas (Figures 1 and 2). Why do you think he did this? T/I

GO TO NELSON SCIENCE

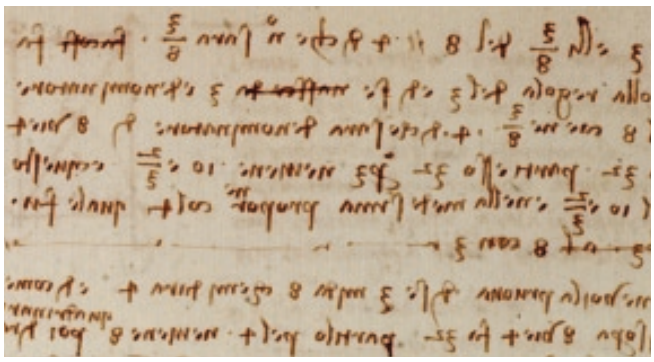

Figure 1 A section from one of Leonardo da Vinci's notebooks showing his backwards writing

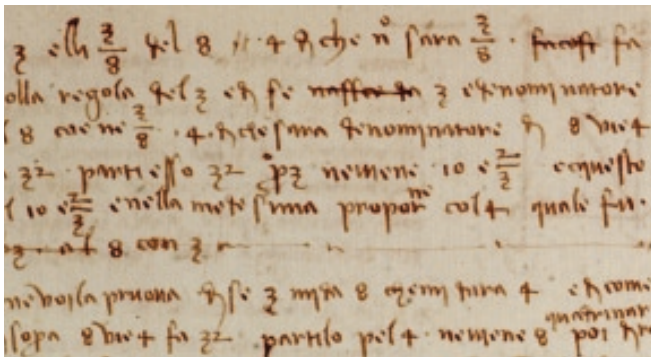

Figure 2 The same section from Figure 1 now reflected in a mirror. Note that the numbers are now readable.

Using Light Rays to Locate an Image

Light rays and the laws of reflection help determine how and where an image is formed in a plane mirror. A light source radiates millions of light rays in all directions, but you are only concerned with the rays that actually strike the mirror and are reflected into your eyes. These rays are reflected off the mirror, with the angle of incidence being equal to the angle of reflection.

To learn more about producing multiple images of an object in plane mirrors, try the activity below.

TRY THIS PRODUCING IMAGES, AND MORE IMAGES, AND MORE IMAGES ...

SKILLS MENU: Predicting, Observing, Analyzing

SKILLS HANDBOOK 3.B.

Equipment and Materials: two plane mirrors; two mirror supports; ruler; protractor; a die; paper; pencil

1. Place the two mirrors at right angles to each other at the top of the sheet of paper. Place the die directly in front of the right angle formed by the mirrors (Figure 3). Record how many images you see in the mirrors.

Figure 3

2. Gently move one of the mirrors, changing the angle between the two mirrors, until you see four complete images. Draw lines on the paper at the base of the two mirrors. Measure and record the angle between them.
3. Now gently move one of the mirrors until you see five images. Again, draw lines on the paper at the base of the two mirrors. Measure and record the angle between them.
4. Based on your previous results, predict what angle between the mirrors would produce six images, then seven, eight, nine, and so on.
5. Continue moving the mirrors, counting the total number of images, and measuring the angle between the mirrors as long as you are able to.

A. How many images were visible when the mirrors were at right angles to each other? T/I

B. Use your knowledge of light rays to explain why this number of images was formed. K/U T/I

C. What was the angle between the mirrors for four images? T/I

D. What was the angle between the mirrors for five images? T/I

E. Were your angle predictions correct for six, seven, eight, and nine images? If not, explain why. T/I

F. What was the total number of images that you were able to count? Why were you not able to exceed this value? T/I

G. A hall of mirrors in an amusement park seems to produce an infinite number of images when you look into it. This effect is also commonly seen in elevators that have two plane mirrors on opposite walls (Figure 4). T/I C A

   (a) Suggest a reason why elevator designers use this effect.

   (b) On a piece of paper, draw two plane mirrors that are parallel to each other. Add light rays to show how this set-up can produce multiple images.

Figure 4 Multiple images produced by parallel plane mirrors

DID YOU KNOW?

Virtual Reality

The word "virtual" in virtual reality also refers to something that does not really exist, or something that is imaginary.

From everyday experience, you know that light travels in a straight line. This belief is so strong that when your eyes detect reflected light from a plane mirror, your brain projects these light rays backwards in a straight line. This results in your brain thinking that there is a light source *behind* the mirror and that this is where the light rays originate (Figure 5). It is this apparent light source behind the mirror that results in you seeing an image behind the mirror. There is, of course, no real light source behind the mirror because the mirror is opaque. This kind of image is called a virtual image. A **virtual image** is an image in which light does not actually arrive at or come from the image location. The light only *appears* to come from the image (Figure 6). Your eyes detect the light rays, but your brain determines where the image is located. You will learn more about the eye in Chapter 13.

virtual image an image formed by light coming from an apparent light source; light is not arriving at or coming from the actual image location

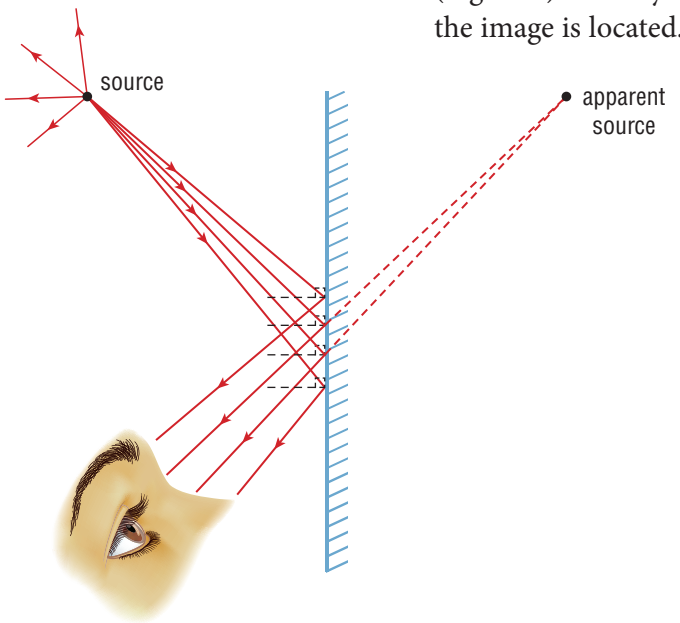

Figure 5 Light rays and the laws of reflection can be used to explain how the eye forms an image of the light source behind the opaque mirror. Note that only light rays that are reflected off the mirror and into your eyes contribute to the location of the apparent source.

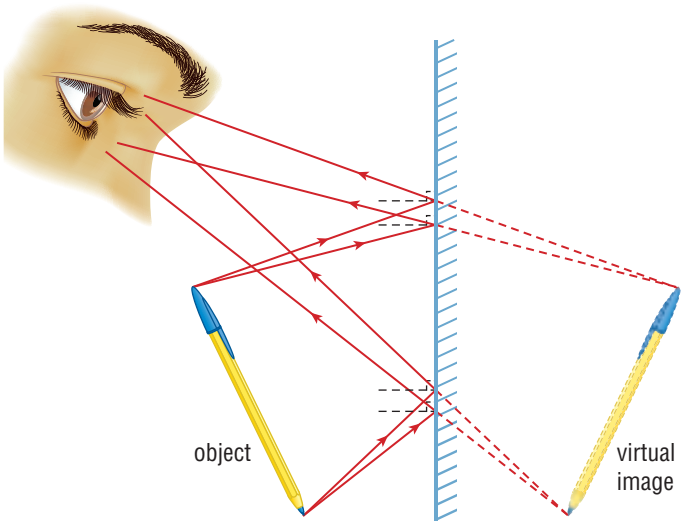

Figure 6 Note that light rays behind the mirror are drawn as dashed lines. This indicates that these rays do not really exist. Your brain projects these rays behind the mirror and forms a virtual image behind the mirror.

DID YOU KNOW?

Playing With Light

A kaleidoscope is a toy that consists of three mirrors that reflect multiple images of an object. The mirrors are mounted in a tube at 60° to one another, with the viewer looking in one end and light coming in from the other end through a screen. Many pleasing hexagonal images are produced as the tube is rotated. The kaleidoscope was invented in England in 1816 by David Brewster.

Using Equal Perpendicular Lines to Locate an Image

You can use light rays and the laws of reflection to show how a plane mirror produces a virtual image and where that is located. The use of light rays also demonstrates another interesting property that allows you to locate the image more directly. Consider again how light rays and the laws of reflection can be used to show how the human eye forms an apparent light source behind an opaque mirror (Figure 5). This time, however, draw a line between the original object and the location of the image. This is the object–image line. There are two interesting observations to make about an object and its image in a plane mirror:

1. The distance from the object to the mirror is exactly the same as the distance from the image to the mirror. In other words, the image appears to be located the same distance behind the mirror as the object is in front of the mirror.
2. The object–image line is perpendicular to the mirror surface.

Both observations can be stated like this: A plane mirror divides the object–image line in half and is perpendicular to that line (Figure 7). The use of equal perpendicular lines allows you to easily locate the image of an object. All you need to do is pick several points on the object and then use the object–image lines and the mirror to locate the image. When you have enough points, you can draw the virtual image (Figure 8). This method does not require you to draw light rays or to measure any angles of incidence and reflection.

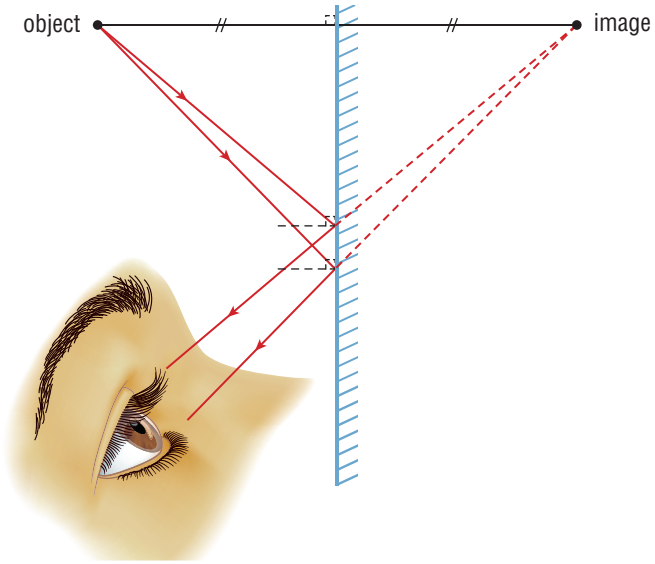

Figure 7 A plane mirror divides the object-image line in half and is perpendicular to that line. This method can be used to locate the image of an object without using light rays.

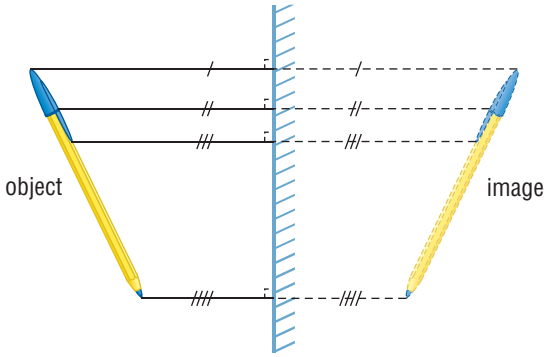

Figure 8 By choosing enough points on an object and drawing a series of object–image lines and lines of equal length that are perpendicular to the mirror, you can accurately locate the virtual image of the object. Note that the image is drawn with dashed lines to indicate that it is a virtual image.

Characteristics of an Image in a Plane Mirror

There is another interesting property of images formed in plane mirrors. The image in a plane mirror is upright but flipped horizontally compared to the object. If you look at more than one letter in a plane mirror, such as the word **SCIENCE** (Figure 9), you will notice that the order of the letters is also reversed. In other words, each letter is flipped horizontally *and* the letters are in reverse order. This property is called **lateral inversion** (Figure 10).

lateral inversion the orientation of an image in a plane mirror that is backwards and in reverse order

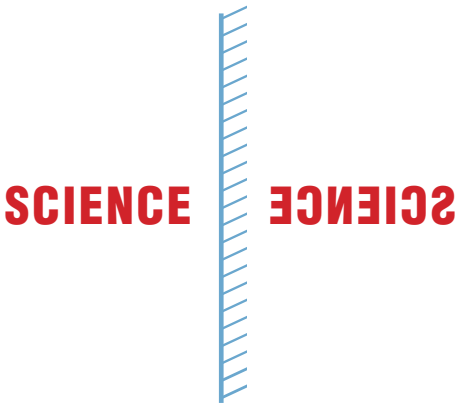

Figure 9 How the image of a word appears in a plane mirror

Figure 10 The writing on the hood of an ambulance is laterally inverted.

DID YOU KNOW?

Saving Money With Mirrors

The use of large plane mirrors in interior designs and movie productions saves money. The mirrors are placed appropriately so that a corridor seems twice as long, when, in reality, it is just a reflection of a shorter corridor in front. Science fiction movies often use this technique when filming images of futuristic machinery stretching off into the distance.

To learn more about the work of interior designers and how they use mirrors,

GO TO NELSON SCIENCE

The Acronym SALT

When you describe the properties of an image, you need to examine four characteristics:

1. size of image (compared to the object: same size, smaller, or larger)
2. attitude of image (which way the image is oriented compared to the object: upright or inverted)
3. location of image
4. type of image (real or virtual) A real image is an image formed when light is actually arriving at the image location. You will learn more about real images in Section 11.9.

Use the acronym **SALT**, for **S**ize, **A**ttitude, **L**ocation, and **T**ype, to remember these four image characteristics (Figure 11).

An image in a plane mirror is always the same size as the object (**S**ize), upright but laterally inverted (**A**ttitude), behind the mirror (**L**ocation: the same distance behind as the object is in front), and virtual (**T**ype).

	Size	Attitude	Location	Type
Image	larger or same or smaller	upright or inverted	object ? image	virtual or real

Figure 11

UNIT TASK Bookmark

Think about how you can use ray diagrams and the laws of reflection as you work on the Unit Task described on page 588.

IN SUMMARY

- When reflected light off a plane mirror enters your eyes, your brain projects these rays backwards to form an apparent light source located behind the mirror.
- A virtual image is formed by the apparent light source because no light rays are actually arriving at or coming from the image location.
- A plane mirror divides the object–image line in half and is perpendicular to that line.
- The acronym **SALT** (for **S**ize, **A**ttitude, **L**ocation, and **T**ype) can be used to remember the four image characteristics.
- An image in a plane mirror is always the same size as the object, virtual (behind the mirror), upright, and laterally inverted.

CHECK YOUR LEARNING

1. In your own words, describe what is meant by the term "virtual image." K/U
2. You stand 1.8 m in front of a plane mirror as you are brushing your teeth. Use SALT to describe the characteristics of the image. K/U
3. You are wearing a T-shirt that has the word "OPTICS" on it. You stand in front of a plane mirror. Write in your notebook how this word appears to you as you look in the mirror. K/U
4. Copy Figure 12 into your notebook. Use a ruler and a protractor to draw normals and reflected rays for the two incident rays. Then project these reflected rays to locate the apparent source behind the mirror. (Refer to Figure 5 in this section for help with this.) Verify your answer using an object–image line and lines of equal length that are perpendicular to the mirror. T/I C

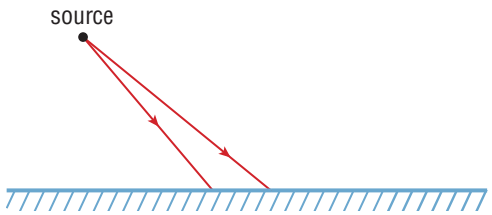

Figure 12

5. Copy all three parts of Figure 13 into your notebook, leaving plenty of space around each part. Draw object–image lines and lines of equal length that are perpendicular to the mirror to determine the image of each object. Use SALT to describe the characteristics of each image. T/I C

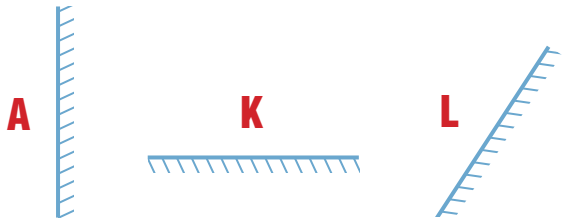

Figure 13

6. (a) What does the acronym SALT stand for?
   (b) In your own words, write a brief explanation of each of these four terms. K/U
7. Emergency vehicles make use of lateral inversion when painting words and pictures on the hoods. Why do you think this is so? Write a brief explanation, including examples of how this is used in your community. K/U A
8. Explain how the backwards writing in a mirror in the activity "Writing Reflectively" demonstrates the properties of an image in a plane mirror. K/U A
9. Your parents have bought a new mirror for your bedroom. At first, you are dismayed because the mirror is only half your height and you do not think that you will be able to see an image of your entire body. You immediately notice, however, that the mirror does allow you to see your entire body. Copy Figure 14 into your notebook and use light rays to show that you really can see your feet in the mirror the way it is set up. T/I C

Figure 14

10. Brainstorm to create a list of effects interior designers might create using mirrors. Explain each effect using what you have learned about light and reflection. K/U A
11. A periscope is a device that is used to see around corners, over a wall, or above water. Simple periscopes contain two plane mirrors.
    (a) Predict how these mirrors are arranged.
    (b) Draw a diagram to illustrate how such a periscope would work. T/I C
12. Were you surprised to learn that your brain can be "fooled" into thinking that an apparent source (virtual image) can be located behind an opaque plane mirror? Discuss this with a partner. C